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A COMPARISON OF THE VIGILANCE PERFORMANCE OF MEN AND WOMEN USIN--ETC(U)
MAR 78 R S THACKRAY, R M TOUCHSTONE

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16. Abstract

The present study examined the question of possible sex differences in the ability to sustain attention to a complex monitoring task requiring only a detection response to critical stimulus changes. The visual display was designed to approximate a futuristic, highly automated air traffic control radar display containing computer-generated alphanumeric symbols. Twenty-six men and an equal number of women were each tested over a 2-hour session. Sixteen targets appeared on the screen at all times, with 10 signals (a designated change in the alphanumerics) randomly presented during each half hour of the test session. Detection latency to the signals increased significantly during the session, but there was no evidence of any significant difference between the sexes in the magnitude or pattern of this increase. The results are discussed in terms of a general decline in alertness that was apparently equal for both sexes.

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A COMPARISON OF THE VIGILANCE PERFORMANCE OF MEN AND WOMEN USING A SIMULATED RADAR TASK

I. Introduction.

The increasing automation of air traffic control (ATC) systems is gradually changing the role of the controller; he/she is becoming less of an independent participant in traffic control and more of a monitor or overseer of a complex computerized system. This gradual change in role places an increasing premium on the ability to sustain a high, consistent level of attention to a task in which the controller may intervene only occasionally. Since individuals who find it difficult to sustain attention under decreased task-load conditions would appear to be more likely to commit errors and less able to handle a sudden emergency situation, it would seem desirable to examine the characteristics of those individuals who find it difficult to sustain attention under such conditions. Much of our research over the past several years has been directed toward this end (11,12,13).

Of the various subject variables or individual characteristics that may relate to the ability to sustain attention during monitoring performance, sex is one that has received relatively little direct attention (2). Davis and Tune (2) suggest that this lack of interest may be understandable, if it is assumed that there are no good a priori reasons why sex differences should be of any practical importance. At the present time, however, active programs are underway in the FAA to recruit more women into ATC occupations, and it is thus of practical importance to determine whether significant sex differences do exist in the ability to effectively monitor increasingly automated radar displays.

Those vigilance studies that have included sex as a variable have employed relatively simple monitoring tasks and have generally considered sex differences to be of secondary interest (1,3,9,10,15,17). Significant sex differences, when obtained, are typically manifested as higher order interactions with more primary task or environmental variables. Because of the conflicting array of findings, it is difficult to arrive at any clear understanding of the influence of sex per se from these data.

Of the studies reviewed, apparently only one vigilance study has treated sex as the single variable of interest. Waag, Halcomb, and Tyler (16) tested 220 men and an equal number of women on a simple visual monitoring task for a period of 1 hour. Both sexes showed parallel declines in percent detection over the task period, but men were significantly superior, $F(1/438) = 18.76$, $p < .001$, to women in the percentage of signals detected for all time periods examined. In terms of the overall magnitude of this difference, men consistently detected about 10 percent more signals than did women.

Because of the large sample size employed in the above study, the statistical likelihood that these data are the result of chance factors would appear to be rather low. Consequently, their findings strongly suggest the possibility that a small but significant superiority of men may exist in the performance of simple vigilance tasks. However, even if a replication of this study verified these findings, this would not necessarily imply that significant sex differences would be expected in complex monitoring performance. Kibler (6) has convincingly argued that complex monitoring tasks differ in so many respects from simple vigilance tasks, that to generalize without verification from simple to complex monitoring performance is unwarranted on the basis of our existing lack of knowledge concerning the degree of relationship between performance on these two "types" of tasks.

The intent of the present study, then, was to determine whether men and women differ in the ability to sustain attention during performance of a complex monitoring task. The task was designed to approximate a futuristic, highly automated ATC system in which the observer monitored alphanumeric symbols for infrequent but "critical" changes. Performance was measured in terms of latency to detect these stimulus changes. In addition to measuring mean latency, maximum and minimum latencies were also obtained. The results of several previous studies of complex monitoring (5,13,14) suggest that maximum latencies reflect lapses of attention or failures to maintain scanning, while minimum latencies provide an estimate of the individual's maximal state of alertness at any given period during the course of a monitoring session. It seemed desirable to include these measures along with mean latency in order to more completely assess possible sex differences in performance.

II. Method.

Subjects. Twenty-six men and twenty-six women served as subjects (S). All were selected from the general population (e.g., college students, housewives) and were paid for their participation. Their ages ranged from 18 to 29 years. None had any prior experience with the task used nor did any have any training in air traffic control.

Apparatus and Task Design. All task programing and recording of responses were accomplished by using a Digital Equipment Corporation (DEC) PDP-11/40 computer. The computer was interfaced with a VT-11 (DEC) 17-inch cathode-ray tube (CRT), which served as the S's display. The CRT was located in a console resembling an air traffic control radar unit. The stimuli (targets) consisted of small rectangular "blips" representing the locations of given aircraft. Adjacent to each target was an alphanumeric data block. Data blocks comprised two rows of symbols: the top row, consisting of two letters and three numerals, identified the aircraft, while the bottom row of six numerals indicated its altitude and speed. The first three of these numerals gave altitude in hundreds of feet and the last three gave groundspeed. For a given target, the alphanumerics identifying the aircraft and its altitude and groundspeed, as well as its entry and exit points, were randomly determined except for the following restrictions: (i) altitudes had to fall within the range of 180 to 600 (in hundreds of feet); (ii) groundspeeds had to fall within the range of 400 to 580 (in knots); and (iii) the entry and exit points for a given target could not be separated by less than 30° along the circumference of the simulated radar screen.

At the beginning of an experimental session, the screen contained 16 targets. A simulated radar sweepline made one complete clockwise revolution every 6 seconds. A target was updated as to location and any change in its data block moments after the sweepline passed the target's prior location. Targets normally moved in a linear fashion unless a course change was programed to avoid target overlaps. The overall impression was one of a pattern of targets moving in discrete jumps as the sweepline passed. This movement approximates very closely the way in which targets are updated in contemporary air traffic control radars with computer-generated alphanumeric displays. The critical stimulus or signal to which the S was instructed to respond consisted of 999 appearing in the altitude block. Ten such critical stimuli appeared in each 1/2-hour period; five occurred in the first 15 minutes and five in the second. The mean intersignal interval was 3 minutes. Time of critical stimulus occurrence and the target in which it occurred were randomly determined with the restriction that two targets could not contain critical stimuli at the same time. The S's response to a critical stimulus consisted of pressing a button located on the console and then holding a light pen over the critical target. The light pen caused the altitude portion of the data block to revert to its previous value. If the S failed to detect a critical stimulus within 1 minute, the data block automatically reverted to its previous value.

The computer and other recording apparatus were located in an adjacent room from which the S was visible through a one-way mirror. Indirect lighting was used in the S's room, and the level of illumination at the display was 2 foot-candles. This level approximates that used in operational air traffic control environments. Figure 1 shows the S's console with a typical stimulus pattern displayed on the CRT.

Procedure. On arrival the S was taken to the testing room and given orientation instructions. The task instructions emphasized the necessity of pressing the button immediately on detection of a critical stimulus. The S was told that the critical stimulus represented some form of malfunction not detected by the computerized radar system. Following the taped instructions, the S was given a 3-minute practice period containing three critical stimuli. After the practice period the 2-hour test period was initiated. Personal timepieces were taken from the S before the test period began.

Measurement of the Performance Data. Performance data were computer processed and the following measures shown below were obtained on each S for each 30-minute period. (All latency measures refer to the time from critical stimulus onset to the button press.)

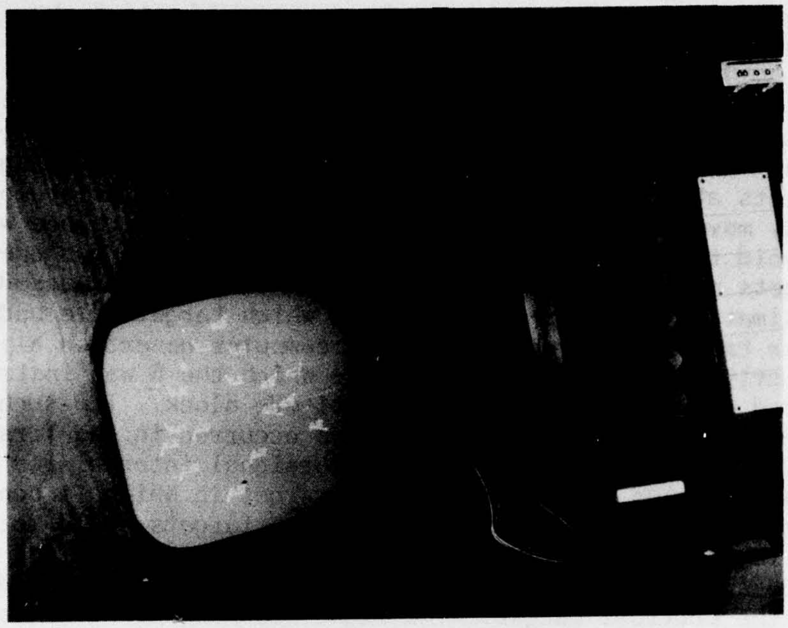

Figure 1. The simulated air traffic control console with a typical stimulus pattern. Only the lower left button was used.

(i) Mean response latency to critical stimuli correctly identified.
(ii) Single longest latency to a correctly identified critical stimulus.
(iii) Single shortest latency to a correctly identified critical stimulus.
(iv) Number of button presses without a critical stimulus.
(v) Number of critical stimuli missed.
(vi) Number of light pen hits to a critical stimulus without a preceding button press.

III. Results.

Figure 2 shows mean detection latencies for all critical stimuli, as well as mean longest and shortest latencies, for both men and women. Analyses of variance applied to these three sets of data revealed significant main effects for the four 1/2-hour periods for mean latencies, $F(3/150) = 9.52$, $p < .01$, maximum latencies, $F(3/150) = 5.05$, $p < .01$, and minimum latencies, $F(3/150) = 4.02$, $p < .01$. Main effects for sex were not significant ($p > .10$) for any of the three response measures, nor were any of the sex-by-periods interactions

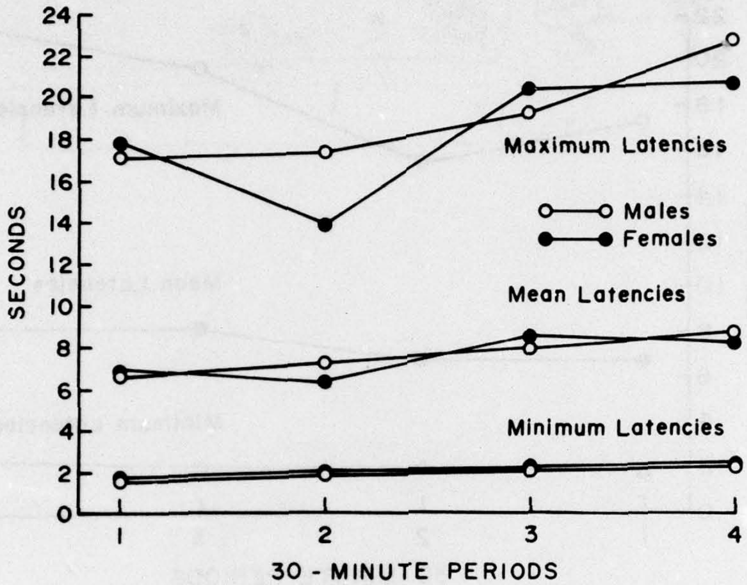

Figure 2. Mean, maximum, and minimum detection latencies for the two sex groups.

significant ($p > .10$). Since there were no significant interaction effects and no differences between the two groups, the data were combined for each of the three measures. These data are shown in Figure 3.

Because the shape of the curve for maximum latencies suggested a possible departure from linearity, trend analyses were conducted on these data, as well as on mean and minimum latencies. Significant linear components were obtained for maximum, $F(1/153) = 10.17$, $p < .01$, minimum, $F(1/153) = 12.12$, $p < .01$, and mean $F(1/153) = 5.59$, $p < .05$ latencies. No quadratic or cubic components were significant ($p > .05$).

The apparent increase, shown in Figure 3, in the range of latencies from the beginning to the end of the session was tested for significance by obtaining the difference between each S's maximum and minimum latencies for each 1/2-hour period. An analysis of variance conducted on these scores revealed that the differences between periods were significant, $F(3/153) = 4.41$, $p < .01$.

As with the previous study in which this task was used (14), errors of omission, commission, and procedure were almost nonexistent. Three critical

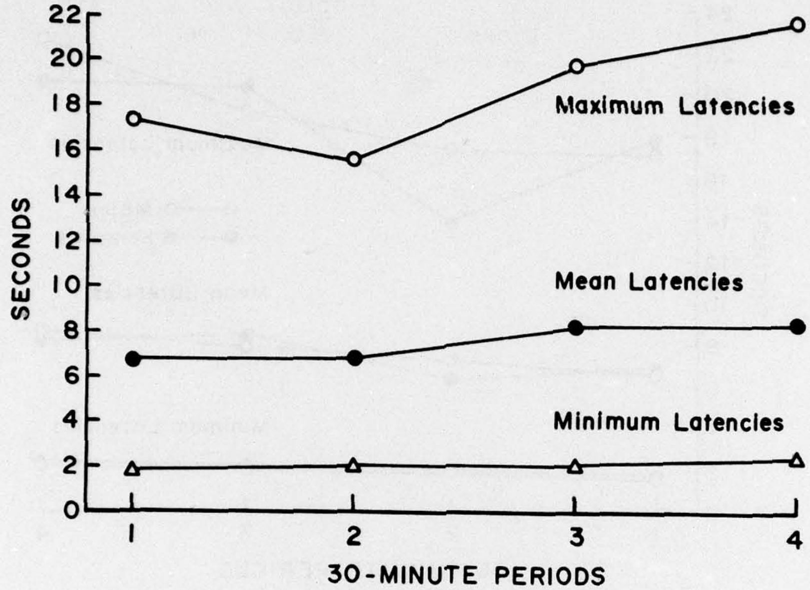

Figure 3. Mean, maximum, and minimum detection latencies for the combined groups.

stimuli were not detected, there were no errors of commission (responses to noncritical targets), and there was only one error of procedure. (A light pen confirmation was made without a preceding button press.)

IV. Discussion.

Both sexes showed significant increases during the session in all latency measures. However, there was no evidence of any difference between men and women in either the magnitude or pattern of change in any of the three measures used. Errors of omission, commission, and procedure were too few in number to allow any sex comparisons.

Although Waag et al. (16) found men to be significantly superior to women in the performance of a simple visual vigilance task, their results are not necessarily in conflict with the findings of the present study. As noted earlier, complex visual monitoring tasks differ in many respects from simple vigilance tasks. At the very least, the former tasks involve a scanning factor in addition to the basic alertness factor involved in simple vigilance performance. On the basis of our present knowledge, there is no reason to assume that both types of tasks would require the same skills or abilities.

Studies are needed in which the same individuals are compared in their performance on both simple and complex monitoring tasks. Such studies have apparently not been conducted. However, a recent factor analytic analysis of complex performance data has revealed that performance of simple monitoring tasks loads on one factor when these tasks are performed in isolation, but on a different factor when the S must engage in scanning and time sharing with other tasks (4). While this evidence does not provide a completely satisfactory answer to the question of the degree of relationship between performance of simple and complex monitoring tasks, it does suggest the possibility that the two tasks may require quite different abilities. Thus, while the present study found no evidence of sex differences in complex monitoring, this does not necessarily preclude the possibility that such differences may exist in the performance of simple vigilance or monitoring tasks. Further research would be required to clearly determine whether sex differences exist in simple vigilance performance. The intent of the present study was to examine possible sex differences only as they might apply to complex monitoring performance.

With regard to the overall performance changes common to both sexes, the results appear to reflect a general decline in arousal level. (An earlier study (14) using the same task conditions revealed performance decrement to be accompanied by a progressive increase in frequency of partial eye closures, along with a decrease in heart rate, palmar skin conductance level, and blood pressure.) This apparent decline in arousal affected all three measures of detection latency, while in our previous study, only maximum and mean latencies showed a significant increase. Since a larger sample was employed in the present study, it is likely that the design used in the earlier one lacked sufficient power to detect the low magnitude changes obtained for minimum latencies.

Studies by Kogi and his associates (7,8) have demonstrated that regular fluctuations of alertness normally occur in tasks requiring sustained visual attention, and that these fluctuations may become more pronounced under conditions producing monotony and drowsiness. Presumably, the increase in range (maximum-minimum) of detection latencies during task performance in the present study was a manifestation of a progressive increase in the amplitude of these fluctuations in alertness. Whether this affected scanning frequency, attentiveness, or some combination of both is a question which will be addressed in future planned research.

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